Geologic Resource Evaluation Scoping Summary
Coronado National Memorial, Arizona

Geologic Resources Division
National Park Service
US Department of the Interior

The Geologic Resource Evaluation (GRE) Program provides each of 270 identified natural area National Park Service units with a geologic scoping meeting, a digital geologic map, and a geologic resource evaluation report. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity for discussion of park-specific geologic management issues and, if possible, include a site visit with local experts. The purpose of these meetings is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and potential monitoring and research needs. Outcomes of this scoping process are a scoping summary (this report), a digital geologic map, and a geologic resource evaluation report.

The National Park Service held a GRE scoping meeting for Coronado National Memorial (CORO) on April 6, 2006, at Coronado National Memorial headquarters. Stephanie O'Meara (CSU) facilitated the discussion of map coverage and Sid Covington (NPS GRD) led the discussion regarding geologic processes and features at the memorial. Floyd Gray (USGS) led a field trip to Coronado Cave and Montezuma Pass after the meeting. Participants at the meeting included NPS staff from the park and Geologic Resources Division, and cooperators from the United States Geological Survey (USGS), Arizona Geological Survey (AZGS), the University of Arizona, and Colorado State University (see table 3). This scoping summary highlights the GRE scoping meeting for Coronado National Memorial including the geologic setting, the plan for providing a digital geologic map, a prioritized list of geologic resource management issues, a description of significant geologic features and processes, lists of recommendations and action items, and a record of meeting participants.

Park and Geologic Setting

Coronado National Memorial was authorized as an International Memorial on August 18, 1941; re-designated July 9, 1952; and established as a National Memorial on November 5, 1952. Coronado NM contains 4,750.22 acres in the Huachuca Mountains, of which 2 acres are nonfederal. Located in a natural setting on the Mexican border, Coronado National Memorial both commemorates the first organized expedition into the Southwest led by Francisco Vasquez de Coronado in 1540 and affirms the ties that bind the United States to Mexico and Spain. Kym Hall (NPS CORO Superintendent) noted that although Coronado NM is a historical memorial, visitors come here to see birds and geology so the staff wishes to improve upon their understanding of the geology at Coronado National Memorial.

Geologic Mapping for Coronado National Memorial

During the scoping meeting Stephanie O'Meara (CSU) showed some of the main features of the GRE Programs digital geologic maps, which reproduce all aspects of paper maps, including notes, legend, and cross sections, with the added benefit of GIS compatibility. The NPS GRE Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation set for the GRE

Program. Staff members digitize maps or convert digital data to the GRE digital geologic map model using ESRI ArcMap software. Final digital geologic map products include data in geodatabase, shapefile, and coverage format, layer files, FGDC-compliant metadata, and a Windows HelpFile that captures ancillary map data.

When possible, the GRE program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, which is often composed of the 7.5-minute quadrangles that contain park lands (figure 1). Maps of this scale (and larger) are useful to resource management because they capture most geologic features of interest and are positionally accurate within 40 feet. The process of selecting maps for management use begins with the identification of existing geologic maps and mapping needs in vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data to be derived by GRE staff.

Map coverage for Coronado NM consists of the following 38 quadrangles of interest mapped at a 1:24,000 scale (outlines shown in red outline on figure 1). Green Valley, Esperanza Mill, Batamote Hills, Elgin, Sonoita, Mount Wrightson, Mount Hopkins, Amado, Saucito Mountain, Fort Huachuca, O'Donnell Canyon, Mount Hughes, Patagonia, San Cayetano Mountains, Tubac, Murphy Peak, Bisbee, Hereford, Nicksville, Miller Peak, Huachuca Peak, Canelo Pass, Harshaw, Cumero Canyon, Rio Rico, Pena Blanca Lake, Ruby, Naco, Stark, Bob Thompson Peak, Montezuma Pass, Campini Mesa, Lochiel, Duquesne, Kino Springs, Nogales, Pajarito Peak, and Alamo Spring. These quadrangles are located on the Chiricahua Peak, Fort Huachuca, Sells, Douglas, Nogales, and Atascosca Mountains 30' x 60' sheets. Table 1 lists the source map chosen for Coronado National Memorial.

Table 1. GRE Mapping Plan for Coronado National Memorial

Covered Quadrangles	GMAP[1]	Citation	Scale	Format	Assessment	GRE Action
Map covers all of the memorial	4155	Gray, Floyd, 2006, Geologic Map of Coronado National Memorial, USGS, unpublished, 1:24000 scale.	1: 24,000	paper and digital	Map covers in extent all of the park.	Conversion of digital data to geodatabase data model; will integrate into FY06 projects.

[1]GMAP numbers are unique identification codes used in the GRE database.

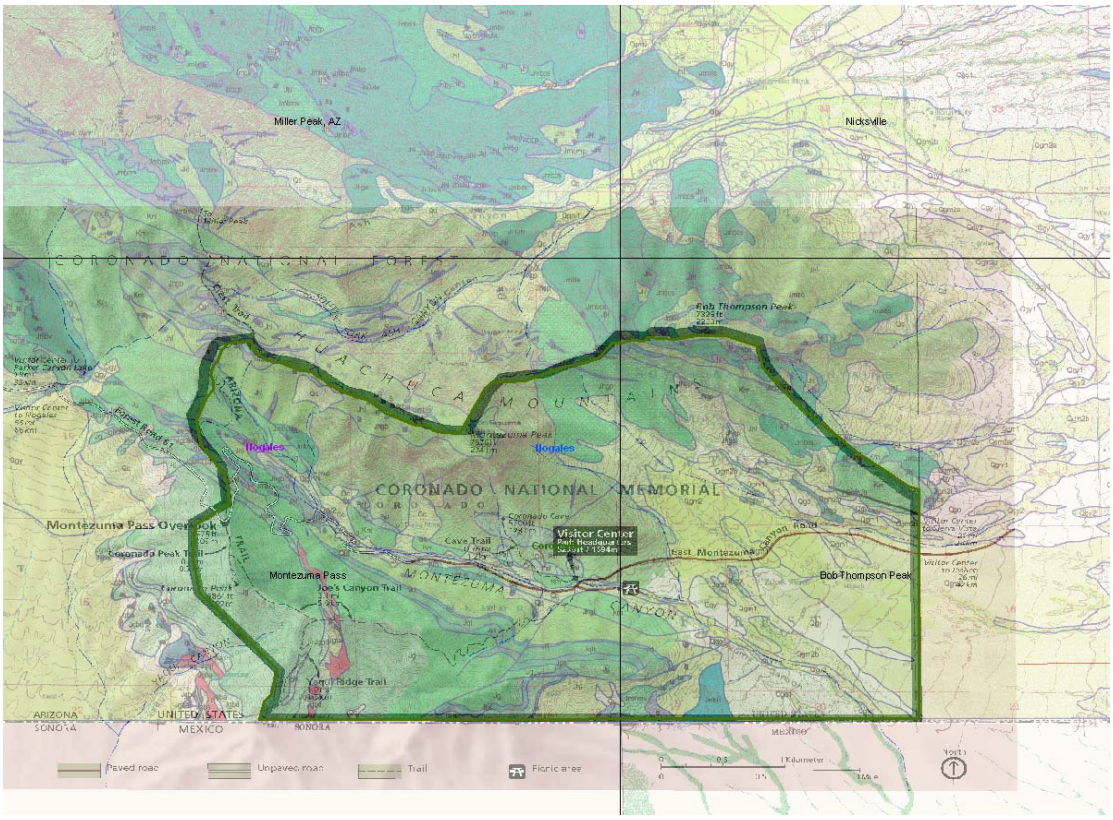

Figure 1. Areas of interest for Coronado National Memorial.

GMAP 4155 (Gray 2006) was the only map determined to be suitable for digitizing. GMAP 4155 covers the park and the adjacent area and is considered to be the best source geologic map (Stephanie O'Meara). Floyd Gray (USGS) used some of Demsey and Pearthree (1994) for GMAP 4155. Hayes and Raup (1968) mapped the Huachuca and Mustang Mountains, but discrepancies, especially regarding folding and faulting, exist in their map (Floyd Gray). When Hayes and Raup mapped the area, geologic mapping was driven by mining interests, but today, habitat is more important than mining so quadrangles are mapped in more detail. The sister park of Coronado NM, across the border in Mexico, has also been mapped by Floyd Gray. Limestone caves exist in that area of Mexico, but except for those in the park, they are all on private land.

GRE mapping action planned for FY 2006 includes:

- The GRE will acquire from Floyd Gray of the USGS digital data for the Coronado National Memorial map (GMAP 4155, USGS unpublished). Expected availability date for the digital data is May/June of 2006 (personal communication with Floyd Gray at scoping meeting). The map covers Coronado NM, as well as the surrounding area. The GRE will evaluate and convert the digital data to the GRE geodatabase data model format. Ancillary text and figures associated with the map will also be acquired and formatted to the GRE format.

Geologic Resource Management Issues

The scoping session for Coronado National Memorial provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRE report. Table 2 presents a summary of potential hazards discussed during the scoping meeting and the issues these hazards may present to management. Although no priority order was discussed at the scoping meeting, the most significant issues are:

(1) Degradation of Coronado Cave, and
(2) Groundwater quantity and quality

Other geologic resource management issues discussed included: impact of illegal aliens on research projects, rockfall, fossils and active faulting in the area.

Table 2. Hazards, features and issues in Coronado National Memorial

Hazard and/or Feature	Issue
Caves/karst	Speleothem and other damage from visitors and the US Military
Groundwater and Surface water	Potential water quantity and water quality issues
Mining	Safety and water quality issues
Illegal aliens	Negative impacts to canyons; impacts visitor safety and geology research projects
Landslides	Potential in some canyons
Flooding	Not an issue
Rockfall	Not an issue
Fossils	Not an issue
Active faults	Not an issue

Coronado Cave

Coronado Cave needs attention. Graffiti, albeit some graffiti is historical and dates to 1892, defaces the cave walls. All cave surfaces, including the speleothems, are covered with dust, and while a nuisance to visitors, the dust also eliminates the cave as habitat for bats. Speleothems have been broken and stolen by visitors. Part of the problem is caused by unrestricted access to the cave. In addition to civilian visitors, US Army personnel from Fort Huachuca routinely use the trail to the cave and the interior of the cave as a training ground, a practice that is contrary to the memorial's mission and that is neither sanctioned by park management (Maggi Daly, NPS CORO) nor appreciated by the visiting public. Ron Kerbo (NPS GRD) and Kelly LaCroix (University of Arizona) are working on a cave management plan for Coronado NM.

Coronado Cave is not the only cave in the park. Barb Alberti (formerly at CORO, now in WHIS, personal communication, April 28, 2006) counted nine cave/karst features in the memorial and thought Jerry Trout was aware of them. Smaller karst features also exist in the park. Kelly LaCroix has located six caves by GPS, although these have not been explored. These caves need to be evaluated and incorporated into the Cave Management Plan. Two other features might be classified as "caves" and "Fly Cave" exists but can't be found (Kelly LaCroix). Coronado Cave is stabilized and new openings are not expected to be found (Ron Kerbo, Kelly LaCroix). No roads or trails have been constructed over known cave/karst features.

Faults do not control cave development in Coronado NM, although limestone fragments are caught up in fault zones. Meteoric water developed the caves while hydrothermal waters are associated with mineral accumulations (Floyd Gray, Charles Ferguson).

Groundwater

Southwest of Coronado NM, a ranch was purchased by developers and a new development consisting of 400 homes is planned for the area (Maggi Daly). Water quantity may become a big issue as groundwater levels may drop due to either drought or demand with new construction. A plume of iron-rich groundwater should be flowing down to that area (Floyd Gray).

The Blue Waterfall is natural, not mine related, and contains low pH water (Charles Ferguson, Floyd Gray). The waterfall is located in a rugged area, off trail, and is not a management issue at this time.

Other Issues

Mining: Mineralization is related to Jurassic intrusions as Cretaceous intrusions are not present in this area (Floyd Gray). Most of the mining in the region is associated with Jurassic skarn deposits that form at the contact of igneous intrusions with sedimentary strata, especially limestone (Charles Ferguson, AZGS).

Barb Alberti mentioned that there are 60 abandoned mineral land (AML) sites in Coronado NM (mine shafts and adits). She thought that most of these were not closed, many were flooded, and the water in some of the mines was good, but in others, the water had a low pH and contained heavy metals. One of the mines had a ph of 2.0. The NPS website for Coronado NM states that most of the AML sites have been posted with warning signs and some of the most dangerous shafts and adits have been closed with cable nets and a few have bat gates across the entrances. The USGS (with data from the old Bureau of Mines) should have a list of these mines (Floyd Gray). According to Floyd Gray, a group of retired citizens sealed many of the mines and put up signs. The State of Texas mine is an abandoned lead-zinc mine with issues of bat habitat (Floyd Gray, Barb Alberti). Twenty-one patented mining claims located on the rangeland downslope from the visitors center were acquired in 1985.

Illegal Aliens: Illegal aliens crossing the U.S.-Mexican border and drug smuggling cause negative impacts to some of the canyons in Coronado. Access into the United States from Mexico can be seen from Montezuma Pass. These border issues impact visitor safety and geology and hydrogeology research projects in these canyons.

Rockfall: While rockfall doesn't seem to be an issue for Coronado NM (Maggi Daly), basalt in Carr Canyon, and possibly some other canyons, has landslide potential (Floyd Gray). Landslides in these canyons may impact roads and trails. Landslide deposits can be seen in the Glance Formation (Jurassic), and could be reactivated.

Fossils: Fossils of marine invertebrates are preserved in the Martin Formation (Devonian) in the Huachuca Mountains, but the Martin Formation is not exposed in the park (Floyd Gray, Charles Ferguson). Structural deformation and contact metamorphism has destroyed most of the fossils in

fault zones. Features resembling algal stromatolites were found on some blocks of limestone and dolomite during the field trip to Coronado Cave. However, fossil poaching is not an issue.

Features and Processes

Some of the features seen on the field trip to Coronado Cave and Montezuma Pass and discussed in the meeting include:

- Coronado Cave and associated speleothems (draperies, columns, stalactites)
- Inverted stratigraphy in a slump block in the Glance Formation (strata in which older strata rest on younger strata)
- Slaty cleavage (tectonic fabric) in the Marietta Formation
- Algal(?) limestone
- Boulder conglomerate of Glance Formation
- "Sky islands"
- Limestone blocks emplaced ("floating") within volcanic rocks in contrast to cohesive limestone strata that Barking Frogs, an endangered species, prefer.
- The "Blue Waterfall", an example of perennial flow of mineral-rich water.

Recommendations

- Develop and implement a cave protection plan

Action Items

No action items were discussed at the scoping meeting

References

Gray, Floyd, 2006, Geologic Map of Coronado National Memorial, USGS, unpublished, 1:24,000 scale (GMAP 4155).

Hayes, P.T., Raup, R.B., 1968, Geologic map of the Huachuca and Mustang Mountains, southeastern Arizona, USGS, I-509, 1:48,000 scale (GMAP 1483).

Demsey, K.A., and Pearthree, P.A., 1994, Surficial and environmental geology of the Sierra Vista Area, Cochise County, Arizona, 5, Open-File Report 94-06, 1:24,000 scale (GMAP 7464).

Table 3. Scoping Meeting Participants

Name	Affiliation	Position	Phone	E-Mail
Covington, Sid	NPS GRD	Geologist	303-969-2154	sid_covington@nps.gov
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